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CHAPTER 1

INTRODUCTION

1.1 Overview

In the first decade of solid state laser discovery, it has developed with huge number of lasing materials and variety of laser designs to optimize the laser performance. However, solid state lasers have reached saturation in its development in recent years. Nowadays, the focus is more on improving and maintaining the solid laser system due to its importance in industrial, medical and military fields. A lot of applications of solid state lasers had been realized in materials processing, holography, range finding, target illumination and designation, satellite and lunar ranging, thermonuclear fusion, plasma experiments, and in general for scientific work requiring high power densities (Koechner, 1976).

1.2 Previous Research

There are researches had been carried out previously regarding Nd:YVO₄ laser crystals in the scope of this study. Some of them are discussed in this section.

Zhang et al (2002), had carried out experiment by using 1.26 at %, 0.95 at %, 0.5 at % and 0.32 at % Nd:doped Nd:YVO₄ crystals with diode pumping power up to 30W. They found out that the laser performance of Nd:YVO₄ increase with decreasing neodymium doping percentage in the crystal until 0.5 at % and the trend change to opposite at neodymium doping lower than 0.5 at %. Therefore, they recommend that 0.5 at % Nd:doped Nd:YVO₄ crystal is the best performer under high pumping power. In the research, 0.5 at % Nd:doped Nd:YVO₄ crystal yields an optical-optical conversion efficiency of 53.0%. The dimension of the 0.5 at % Nd:doped Nd:YVO₄ crystal used in the research is 3 x3 x 8 mm³ (bxcxa). However, in their paper, it is recommended that a high neodymium doped and short crystal for low pumping power while low neodymium doped crystal is suitable for high pumping power with suitable length.

Wang et al (2001), had studied various Nd:YVO₄ crystals with different length and different doping percentage of neodymium. They found out that the 2 mm long crystal with 2.0 at % Nd:doped Nd:YVO₄ is the best laser crystal within the context of the research. This is due to the advantage of the crystal such as economical, high efficiency and low threshold power requirement. With the crystal, they obtain an optical-optical conversion efficiency of 45.4% with threshold of 39mW. One also can note from the result of this experiment, generally, the shorter the length of a crystal, the higher neodymium doping crystal perform better. They

also concluded that 5.0 at % Nd:doped Nd:YVO₄ is the best for 1 mm long laser crystal.

Ding et al (2009), reported that optical-optical conversion efficiency of 54.5 % had been obtained from 1.0 at % Nd:doped Nd:YVO₄ crystal. They come to this conclusion by comparing three pieces of Nd:YVO₄ with thickness of 4 mm and with doping concentrations of 0.4 at %, 1.0 at % and 3.0 at % Nd:doped Nd:YVO₄ crystal. It was found that 3.0 at % Nd:doped Nd:YVO₄ crystal shows a drop in slope efficiency due to higher residual losses in highly-doped crystal. Moreover, for the same crystal, they also observed high threshold due to decrease of the upper level quantum efficiency with increase in doping level.

1.3 Problem Statement

Nd:YVO₄ laser crystals can be formed by doping orthovanadate host with various doping concentrations of trivalent neodymium dopant. The laser performance of Nd:YVO₄ crystals depends on the neodymium doping concentrations and the length of the crystals. The issue is that, previous research only highlight on the high percentage of efficiency, but very seldom consider the damage threshold for each doping level. The duration to withstand or the robustness of the gain medium with high pump power is much more important beside the high performance.

1.4 Research Objective

The main objective of this study is to determine the performance of gain medium Nd:YVO₄ crystal based on doping level. In attempt to achieve this goal, the following works is performed;

1. Calibrate the performance of diode laser as pumping source
2. Pumping gain medium Nd:YVO₄ at various doping level
3. Characterize the slope efficiency and threshold power each of the gain mediums
4. Determine the damage threshold each of gain mediums

1.5 Research Scope

In this research the gain medium under consideration is Nd:YVO₄ crystal. The doping level or the concentration under studied are 0.5 at %, 1.0 at % and 1.5 at % Nd:doped Nd:YVO₄ crystals. The length each of gain medium is remained the same at 1 mm. Laser diode at 808 nm was used as a pumping source. End-pumping technique was conducted. Slope efficiencies and threshold powers are made based on the output's profile and damage is realized based on the observation of crack in the crystal surface.

1.6 Thesis Outline

Chapter 1 reviews some previous researches done related to Nd:YVO₄ laser performance based on its neodymium doping concentration and crystal length. The objective and scope of the study is also discussed.

Chapter 2 covers the literature review related to the study. This includes the fundamentals of laser, fundamentals of solid state laser and thermal management of a laser system.

Chapter 3 describes the preparation of the materials and the method of experiments to collect data for diode laser calibration, output beam characteristics and output optical power measurements.

Chapter 4 shows the data of the experiments and the way that the data are presented. By using appropriate data analysis, the slope efficiencies and threshold power of the crystals are presented and discussed.

Chapter 5 concludes the results of this study and suggests the works to be carried out in future related to this research.